PATENT SPECIFICATION

Application Date: Dec. 13, 1935. No. 34634/35. **467,502**

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Complete Specification Accepted: June 14, 1937.

PROVISIONAL SPECIFICATION

Improvements in or relating to Apparatus for Treatment by means of High Frequency Electromagnetic Waves

We, STANDARD TELEPHONES AND CABLES LIMITED, a British Company, and BERNARD JOHN AXTEN, a British Subject, both of Connaught House, 63, Aldwych, London, W.C.2, do hereby declare the nature of this invention to be as follows:—

This invention relates to apparatus for treatment of bodies by means of high frequency electromagnetic waves, such for example as the so-called diathermy medical treatment.

In such treatment it is frequently found, when the zone to which treatment is intended to be applied is situated within the interior of the body being treated, that there is an unwanted concentration of energy at zones at or near the surface. The concentration of energy within an interior zone is assisted by the use of short and ultra-short waves instead of waves of wavelengths of the order of 300—600 metres, and by the use of insulated electrodes instead of electrodes of the contact type.

The present invention provides an arrangement that also materially aids the desirable conditions. The maximum improvement will result when the invention is used with the known devices mentioned above, but the invention itself is independent of the particular type of electrodes and of the length of waves used.

An arrangement is known in which two pairs of electrodes are disposed about a body in such manner that the desired zone of treatment is situated in the region which is common to the path between the respective pairs of electrodes. This known arrangement is shown diagrammatically in Fig. 1 of the accompanying drawings. A generator X supplies energy to two pairs of electrodes AB and CD which are applied to a body O in such manner that the zone Q upon which it is desired to act is in the intersection of the beams between A and B and between C and D. By suitable location of the electrodes round the body O the concentration zone Q may be located at any desired part of the body. The dimensions of this zone may also be varied by choice of the sizes of the electrodes.

In addition to the main current paths AB and CD, secondary current paths AD and BC are also present. The result is that two other concentration zones occur near the surface of the body O.

According to the present invention, separate pairs of electrodes disposed about a body are supplied with energy having constantly changing phase relationship.

This may be accomplished by supplying the different pairs of electrodes from different generators which are arranged to supply energy of the desired phase in manner to be hereinafter described. The arrangement is shown diagrammatically in Figure 2 of the accompanying drawings in which electrodes A and B are connected to a high frequency generator Y and electrodes C and D to a second high frequency generator X. If now the outputs of the two generators X and Y are arranged to have a constantly changing mutual phase relationship the secondary paths will be alternately AC, DB and AD, BC. The average condition will be that the secondary path energy will be distributed over four paths, instead of two paths as in the arrangement shown in Fig. 1. Thus, there will be four concentration zones towards the surface but of medium intensity instead of two similar zones of great intensity. The result is to produce in an object an approximately even distribution over the surface of the body with freedom from surface concentration effects, but with a central concentration zone at the desired location.

The invention is not limited to two generators supplying two pairs of electrodes. Fig. 3 of the accompanying drawings shows four generators W, X, Y and Z supplying energy to separate pairs of electrodes EF, CD, AB and GH respectively.

Figure 4 of the accompanying drawings shows schematically an arrangement for furnishing two sets of high frequency oscillations having constantly changing mutual phase relationship. A step up

transformer J has its primary winding connected through switches K, K¹ and M to a low frequency alternating current supply. The secondary of the transformer feeds an auxiliary circuit N, P, P¹ connected to a spark gap SG feeding a short or ultra-short wave circuit VG, T, T¹ connected to electrodes L, L_1 in well-known manner. Across the auxiliary circuit N, P, P¹ is connected a second spark gap SG¹ feeding a further short or ultra short wave circuit VG¹, T¹¹, T¹¹¹ connected to electrodes R, R_1. High frequency chokes S, S¹ are interposed between the circuit N, P, P¹ and the spark gap SG¹. When the apparatus is in operation two sets of high frequency oscillations are produced, the high frequency chokes S, S¹ preventing interaction between the two short wave circuits and enabling them to produce oscillations independently of each other. Due to the irregular nature of spark gap discharges and to the fact that each short wave circuit has its own spark gap, the two sets of oscillations produced will have a constantly changing mutual phase relationship.

There is a limit to the voltage that can be applied to the electrodes because of the occurrence of corona effects or direct high frequency discharge between the electrodes. It has hitherto been found that with the highest voltage, capacity and spark frequency permissible the power is limited to a figure which is insufficient for some treatments. By means of the application of the outputs from two or more high frequency generating circuits to separate pairs of electrodes, more power may be applied than is at present possible with spark gap apparatus without increase of voltage, without raisng the capacity and hence the wave length, and without obtaining undesirable energy concentration effects near the surface of the body under treatment. It is to be noted that the arrangement shown in Fig. 4 is more economical and convenient than the use of entirely separate equipments.

Figure 5 of the accompanying drawings shows in schematic form another arrangement for furnishing two independent sets of high frequency oscillations having a constantly varying mutual phase difference. A transformer J has its primary winding connected through a switch K, K¹ to a low frequency alternating current supply. A high tension secondary winding on this transformer provides the anode supply for two valves AC and AM respectively whilst a low tension secondary winding provides filament heating current for the same two valves. The high frequency generating circuit connecting the valve AC with the electrodes L, L_1 is well known and need not be further described. A second similar high frequency generating circuit is provided connecting the valve AM to a second pair of electrodes R, R_1, a high frequency choke S being interposed in the connection of valve AM across the secondary of transformer J.

When the switch K, K_1 is closed, two sets of high frequency oscillations will be produced, one set being applied to electrodes L, L_1 and the other to electrodes R, R_1 and due to the isolating high frequency choke S, these two sets will be mutually independent.

Constantly changing difference in mutual phase relationship is obtained by adjusting the inductance and capacity elements of the two circuits so that two different frequencies are produced. Alternatively, the outputs of the two high frequency generating circuits may be modulated by a different modulation frequency for each oscillator, in which each case for each oscillator, in which case the two generators shown may operate at the same or at different frequencies.

The invention is also useful as applied to the treatment of a body of considerable size as shown diagrammatically in Figure 6 of the accompanying drawings, in which W, X, Y and Z are separate high frequency generating circuits suppied with power from the same source CJ. These separate generators supply pairs of electrodes EF, CD, AB and GH respectively. By the use of independent high frequency generating circuits, a relatively large electrode area is obtainable without an increase of wave length, and by making the phase relations constantly changing undue surface effects are avoided.

The invention is applicable to the high frequency treatment of human or animal bodies, and to such treatment applied for killing insects or bacteria, and for the irradiation of bacteria, or foodstuffs.

Dated this 13th day of December, A.D. 1935.

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Connaught House, 63, Aldwych, London, W.C.2.

COMPLETE SPECIFICATION

Improvements in or relating to Apparatus for Treatment by means of High Frequency Electromagnetic Waves

We, STANDARD TELEPHONES AND CABLES LIMITED, a British Company, and BERNARD JOHN AXTEN, a British Subject, both of Connaught House, 63, Aldwych, London, W.C.2, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to apparatus for treatment of bodies by means of high frequency electromagnetic waves, such for example as the so-called diathermy medical treatment.

In such treatment it is frequently found, when the zone to which treatment is intended to be applied is situated within the interior of the body being treated, that there is an unwanted concentration of energy at zones at or near the surface. The concentration of energy within an interior zone is assisted by the use of short and ultra-short waves instead of waves of wavelengths of the order of 300—600 metres, and by the use of insulated electrodes instead of electrodes of the contact type.

The present invention provides an arrangement that also materially aids the desirable conditions. The maximum improvement will result when the invention is used with the known devices mentioned above, but the invention itself is independent of the particular type of electrodes and of the length of waves used.

The nature of the invention and the manner in which it may be carried out in practice will be understood from the following description taken in conjunction with the drawings accompanying the Provisional Specification and with the accompanying drawing.

An arrangement is known in which two pairs of electrodes are disposed about a body in such manner that the desired zone of treatment is situated in the region which is common to the path between the respective pairs of electrodes. This known arrangement is shown diagrammatically in Fig. 1 of the drawings accompanying the Provisional Specification. A generator X supplies energy to two pairs of electrodes AB and CD which are applied to a body O in such manner that the zone Q upon which it is desired to act is in the intersection of the beams between A and B and between C and D. By suitable location of the electrodes round the body O the concentration zone Q may be located at any desired part of the body. The dimensions of this zone may also be varied by choice of the sizes of the electrodes.

In addition to the main current paths AB and CD, secondary current paths AD and BC are also present. The result is that two other concentration zones occur near the surface of the body O.

Specification No. 315,367 discloses the superposition of oscillating electric discharges produced between condensers standing at an angle to each other, for example at 90°, the frequency, phase differences and amplitudes of which are mutually syntonised for the purpose of producing in a treated substance combination oscillations after the manner of the Lissajous oscillations. Oscillating circuits, including spark gaps, in which such condensers were connected are excited by inductive coupling with a transmitter. An arrangement according to the invention is illustrated diagrammatically in Figure 2 of the drawings accompanying the Provisional Specification in which electrodes A and B are connected to a high frequency generator Y and electrodes C and D to a second high frequency generator X. If now the outputs of the two generators X and Y are arranged to have a constantly changing mutual phase relationship the secondary paths will be alternately AC, DB and AD, BC. The average condition will be that the secondary path energy will be distributed over four paths, instead of two paths as in the arrangement shown in Fig. 1. Thus, there will be four concentration zones towards the surface but of medium intensity instead of two similar zones of great intensity. The result is to produce in an object an approximately even distribution over the surface of the body with freedom from surface concentration effects, but with a central concentration zone at the desired location.

The invention is not limited to two generators supplying two pairs of electrodes. Fig. 3 of the drawings accompanying the Provisional Specification shows four generators W, X, Y and Z supplying energy to separate pairs of electrodes EF, CD, AB and GH respectively.

Figure 4 of the drawings accompanying the Provisional Specification shows schematically an arrangement for furnishing two sets of high frequency oscillations having constantly changing mutual phase relationship. A step up transformer J has its primary winding connected through switches K, K^1 and M to a low frequency alternating current supply. The secondary of the transformer feeds an auxiliary circuit N, P, P^1 connected to a spark gap SG feeding a short or ultra-short wave circuit VG, T, T^1 connected to electrodes L, L^1 in well-known manner. Across the auxiliary circuit N, P, P^1 is connected a second spark gap SG^1 feeding a further short or ultra short wave circuit VG^1, T^{11}, T^{111} connected to electrodes R, R^1. High frequency chokes S, S^1 are interposed between the circuit N, P, P^1 and the spark gap SG^1. When the apparatus is in operation two sets of high frequency oscillations are produced, the high frequency chokes S, S^1 preventing interaction between the two short wave circuits and enabling them to produce oscillations independently of each other. Due to the irregular nature of spark gap discharges and to the fact that each short wave circuit has its own spark gap, the two sets of oscillations produced will have a constantly changing mutual phase relationship.

With spark gap equipment there is a limit to the voltage that can be applied to the electrodes since the capacity in the circuit is limited by the wave length to be used and consequently above a certain voltage brush discharge or even direct discharge may take place between the electrodes. It has hitherto been found that with the highest voltage, capacity and spark frequency permissible the power is limited to a figure which is insufficient for some treatments. By means of the application of the outputs from two or more high frequency generating circuits each using a separate spark gap to separate pairs of electrodes, more power may be applied than is at present possible with spark gap apparatus without increase of voltage, without raising the capacity and hence the wave length, and without obtaining undesirable energy concentration effects near the surface of the body under treatment. It is to be noted that the arrangement shown in Fig. 4 accompanying the Provisional Specification is more economical and convenient than the use of entirely separate equipments.

Figure 5 of the drawings accompanying the Provisional Specification shows in schematic form another arrangement for furnishing two independent sets of high frequency oscillations having a constantly varying mutual phase difference. A transformer J has its primary winding connected through a switch K, K^1 to a low frequency alternating current supply. A high tension secondary winding on this transformer provides the anode supply for two valves AC and AM respectively whilst a low tension secondary winding provides filament heating current for the same two valves. The high frequency generating circuit connecting the valve AC with the electrodes L, L^1 is well known and need not be further described. A second similar high frequency generating circuit is provided connecting the valve AM to a second pair of electrodes R, R^1, a high frequency choke S being interposed in the connection of valve AM across the secondary of transformer J.

When the switch K, K_1 is closed, two sets of high frequency oscillations will be produced, one set being applied to electrodes L, L_1 and the other to electrodes R, R_1 and due to the isolating high frequency choke S, these two sets will be mutually independent.

Constantly changing difference in mutual phase relationship is obtained by adjusting the inductance and capacity elements of the two circuits so that two different frequencies are produced. Alternatively, the outputs of the two high frequency generating circuits may be modulated by a different modulation frequency for each oscillator, in which case the two generators shown may operate at the same or at different frequencies.

An arrangement in which distribution of energy elsewhere than in the required zone is entirely avoided is shown in the accompanying drawing. Two thermionic valves 1 and 2 are used the circuits of each valve being connected so that its input and output circuits are coupled together in any well known manner for the generation of oscillations. The anodes of the valves are fed by the secondary winding of a transformer 3 the primary of which is supplied with alternating current from any suitable source of supply such as the mains. One end of the secondary of transformer 3 is connected to the anode of valve 1, and the other end to the anode of valve 2. Output circuits 7 and 8 are coupled to the inductances 5 and 6 of the respective tuning circuits of the valves 1 and 2 and a pair of electrodes is connected to each of these output circuits. It is clear that the valves 1 and 2 are oscillating during alternate half cycles of the anode feed current but that valve 1 is never generat-

ing any oscillatory current whilst valve 2 is also oscillating and vice versa. If now the respective pairs of electrodes connected to the circuits 7 and 8 are placed as shown in Fig. 2 of the drawings accompanying the Provisional Specification, the average value of the field in the area Q will be appreciably greater than at any point towards the surface of the object.

The apparatus shown in this figure has considerable commercial advantages, since it is adaptable for a variety of uses. Suitable switches can easily be arranged so that either or both oscillators may be used, and so that the outputs of the two valves may be connected either to separate output circuits as shown or in parallel to a single output circuit. Assuming that the output of each oscillator is 300 Watts; the apparatus may then be used with one oscillator only where an output of 300 Watts is required; with two oscillators feeding into two separate output circuits for the treatment of two bodies simultaneously with 300 Watts each; or for the treatment of a single body with a concentration of 600 Watts in a desired interior zone by means of the crossing of the fields between the separate pairs of electrodes; or with the two oscillators feeding in parallel into a single output circuit giving an output of 600 Watts which is valuable in certain treatments, as for example the production of artificial fever in a patient.

The invention is applicable to the so called diathermic treatment of human or animal bodies and also to the treatment of other bodies for killing insects or bacteria or for other purposes.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. Apparatus for treating a body by means of high frequency electromagnetic energy comprising a plurality of spark gaps with a separate pair of electrodes for application to the body and a separate frequency determining circuit connected to each spark gap, and a common auxiliary circuit for exciting all of the spark gaps, for the purpose specified.

2. Apparatus for treating a body by means of high frequency electromagnetic energy comprising a plurality of thermionic valve oscillators, a separate pair of electrodes for application to the body connected to each oscillator, a common source of alternating current power supply for each of the oscillators and means for ensuring a continuous change in the phase relation between the oscillations supplied to the separate pairs of electrodes.

3. Apparatus for treating a body by means of high frequency electromagnetic energy comprising a plurality of thermionic valve oscillators, a separate pair of electrodes for application to the body connected to each oscillator, a common source of power supply for each of the oscillators and means for connecting positive potential from said power supply to the anode of each of the oscillators in rapid succession so that one only of the oscillators is active at each instant.

4. Apparatus as claimed in Claim 2, in which said continuous change in the phase relation is obtained by tuning the said oscillators to different frequencies.

5. Apparatus as claimed in Claim 2, in which said continuous change in the phase relationship is obtained by modulating the oscillations produced by the said valve oscillators with different frequencies before supplying said oscillations to the respective pairs of electrodes.

6. Apparatus as claimed in Claim 3, comprising a pair of thermionic valve oscillators and an alternating power supply for the anodes of said oscillators oppositely connected to said anodes.

Dated this 30th day of October, A.D. 1936.

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[This Drawing is a reproduction of the Original on a reduced scale.]

Fig. 1.

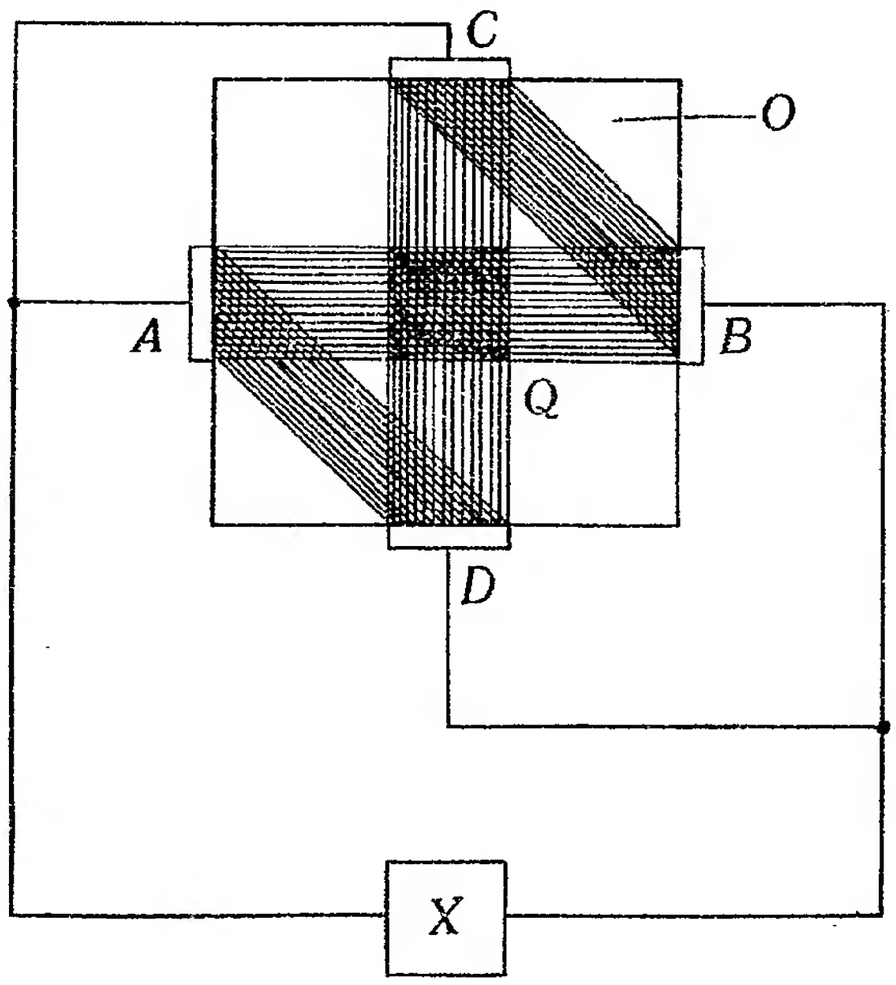
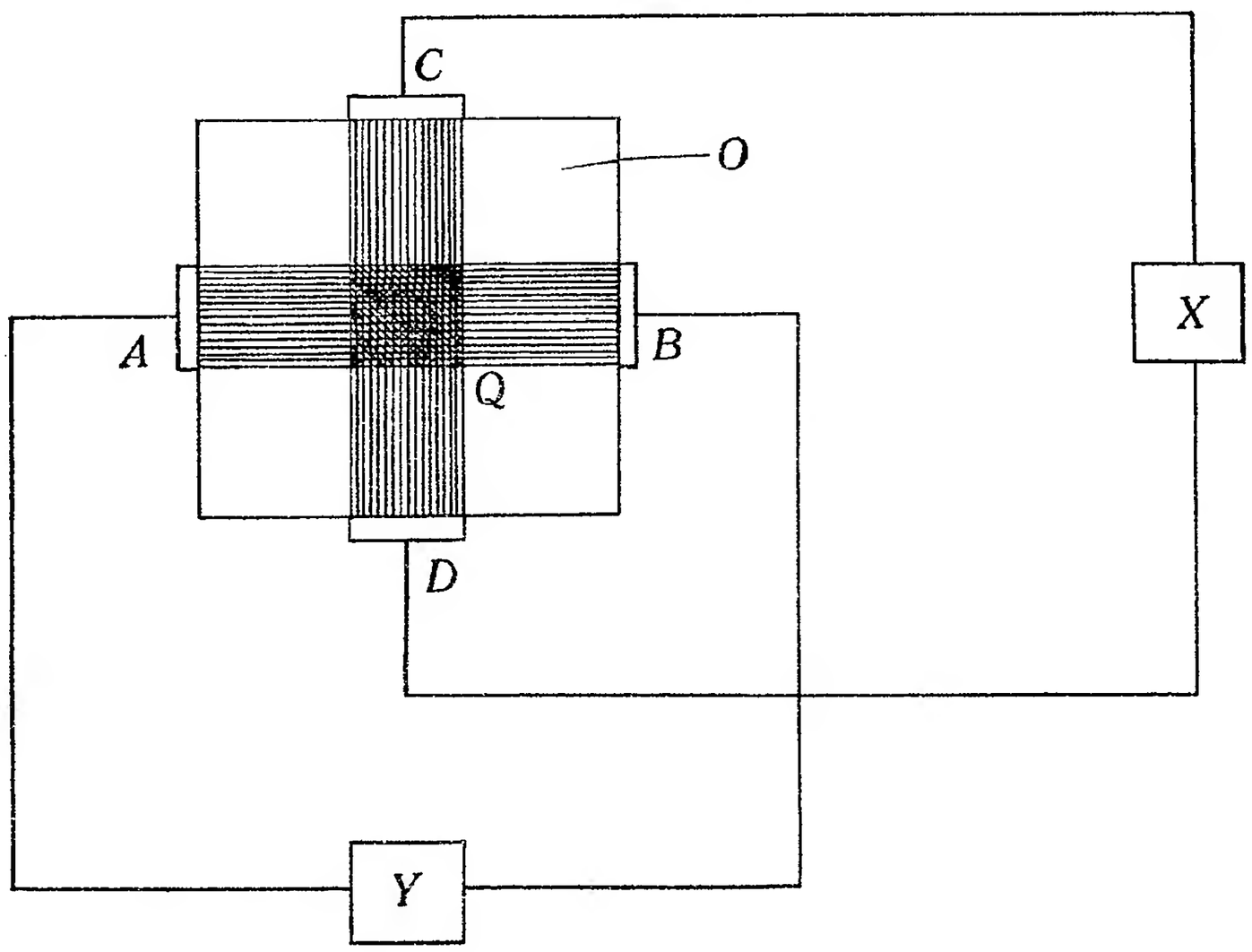


Fig. 2.



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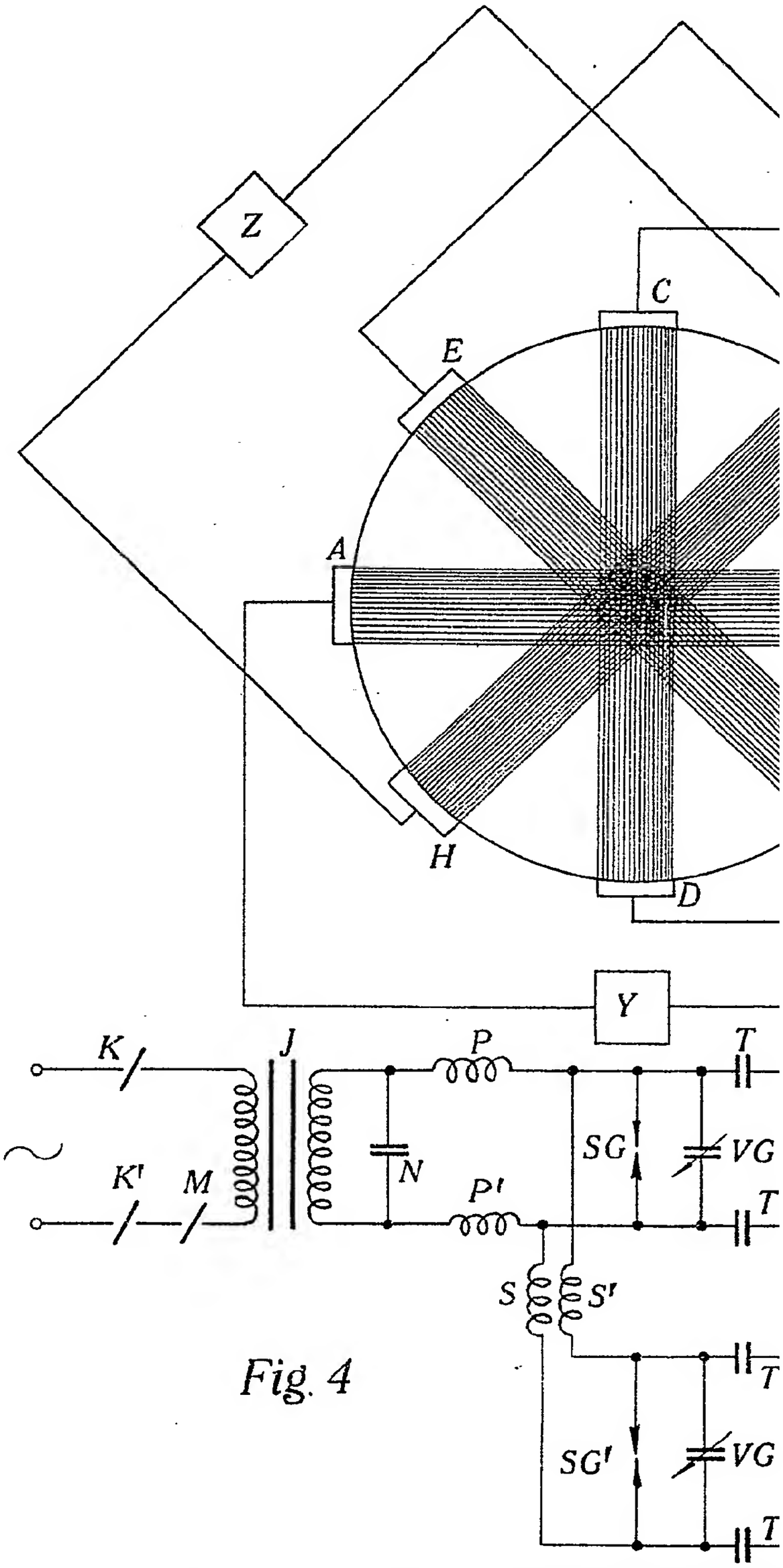

Fig. 4

Fig. 3.

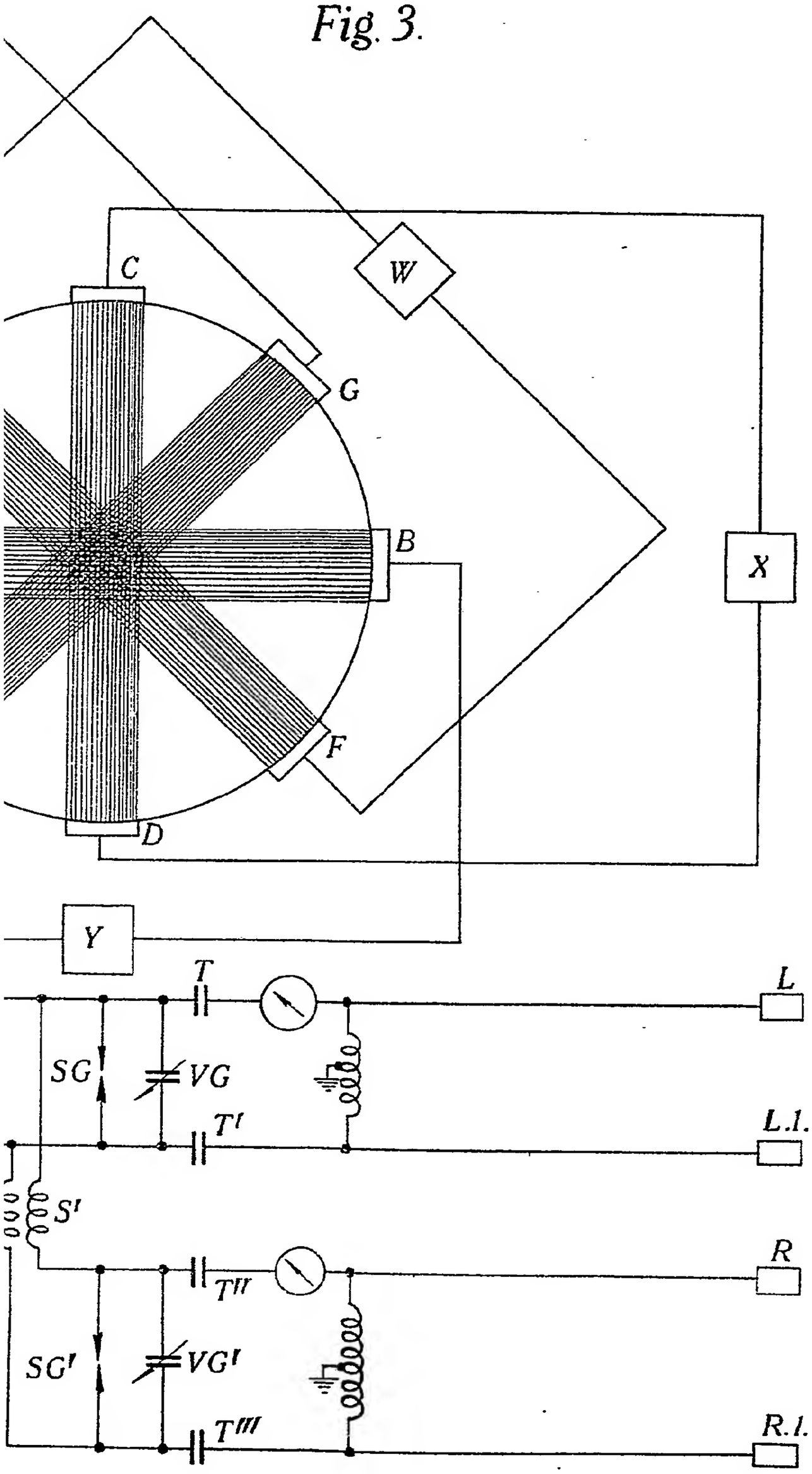

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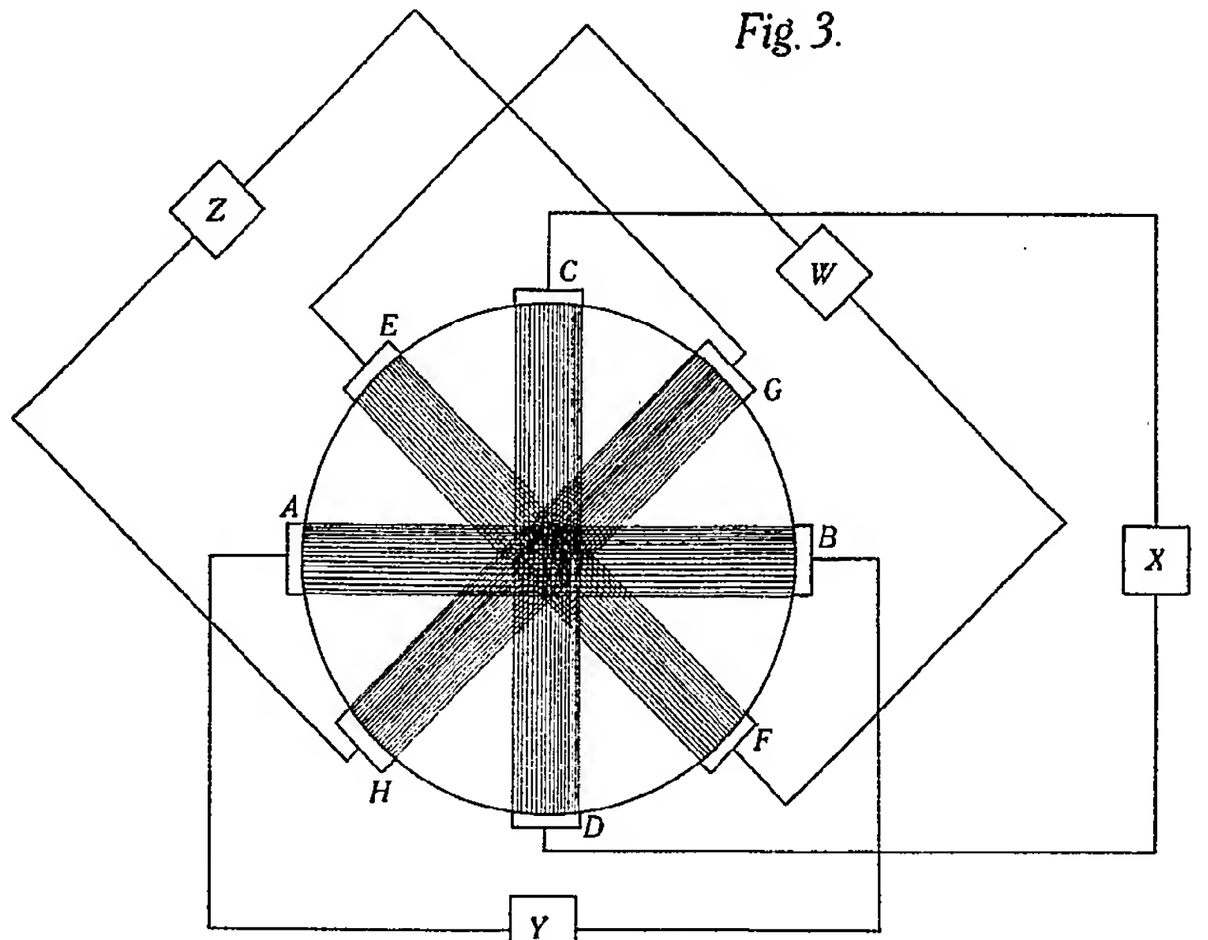
Fig. 3.



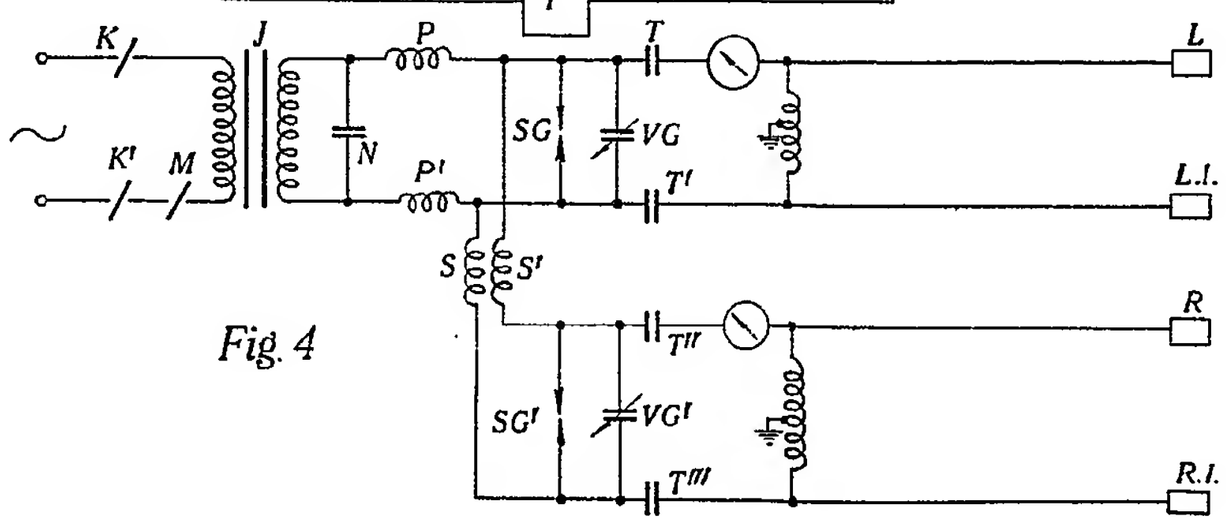


Fig. 4

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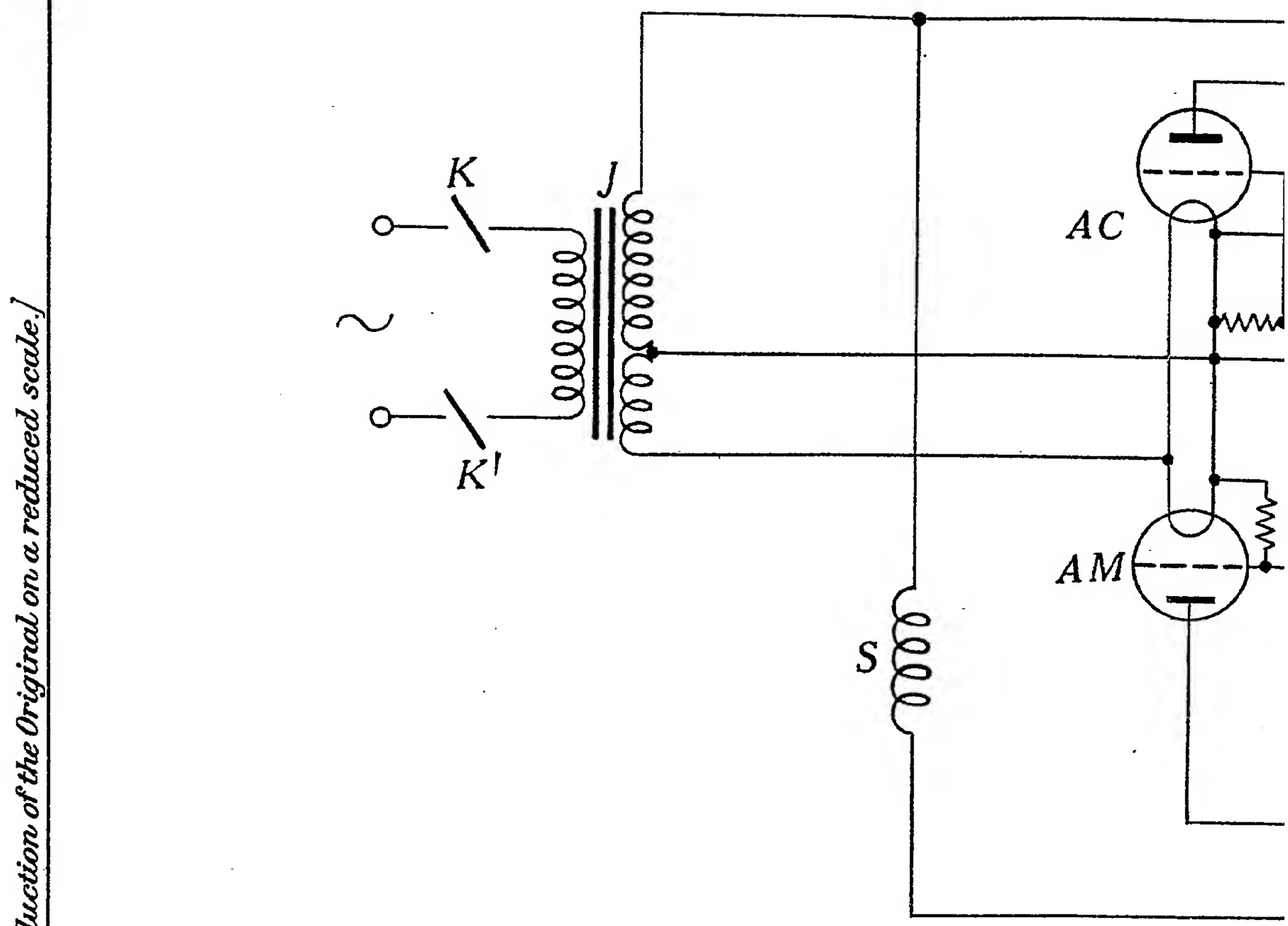

Fig. 6.

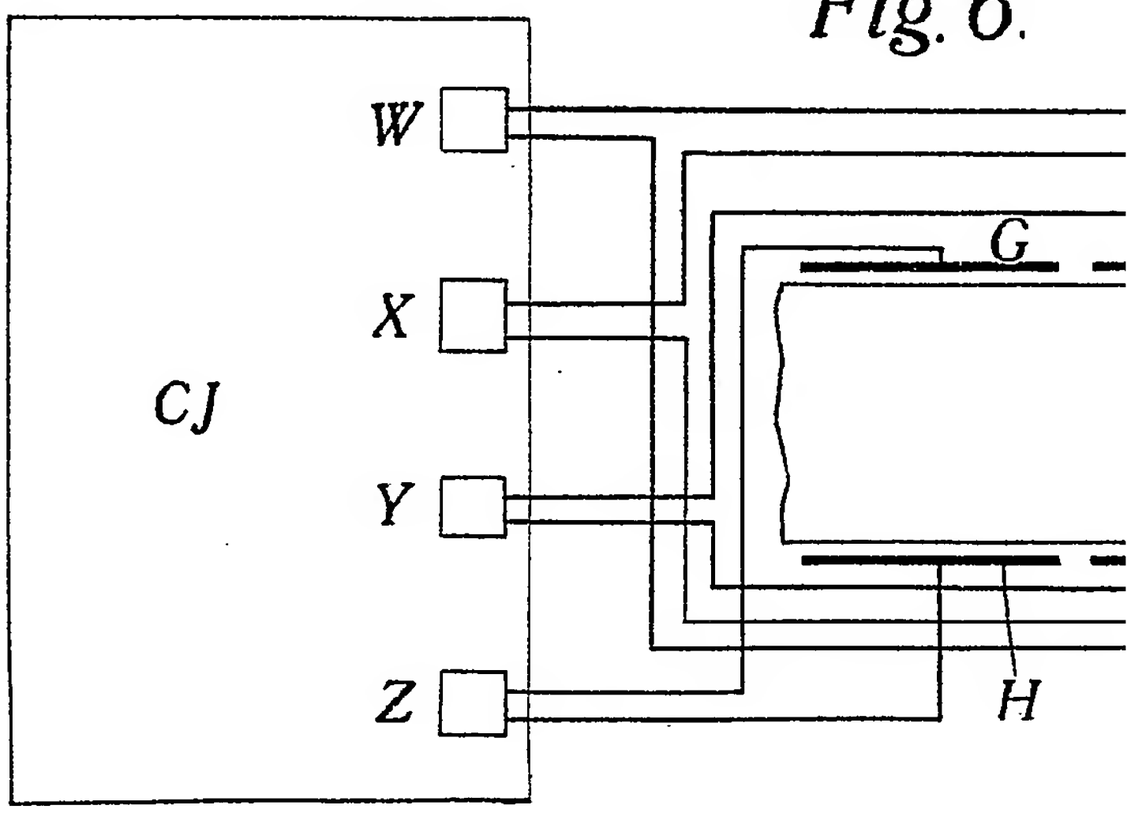

Fig. 5.

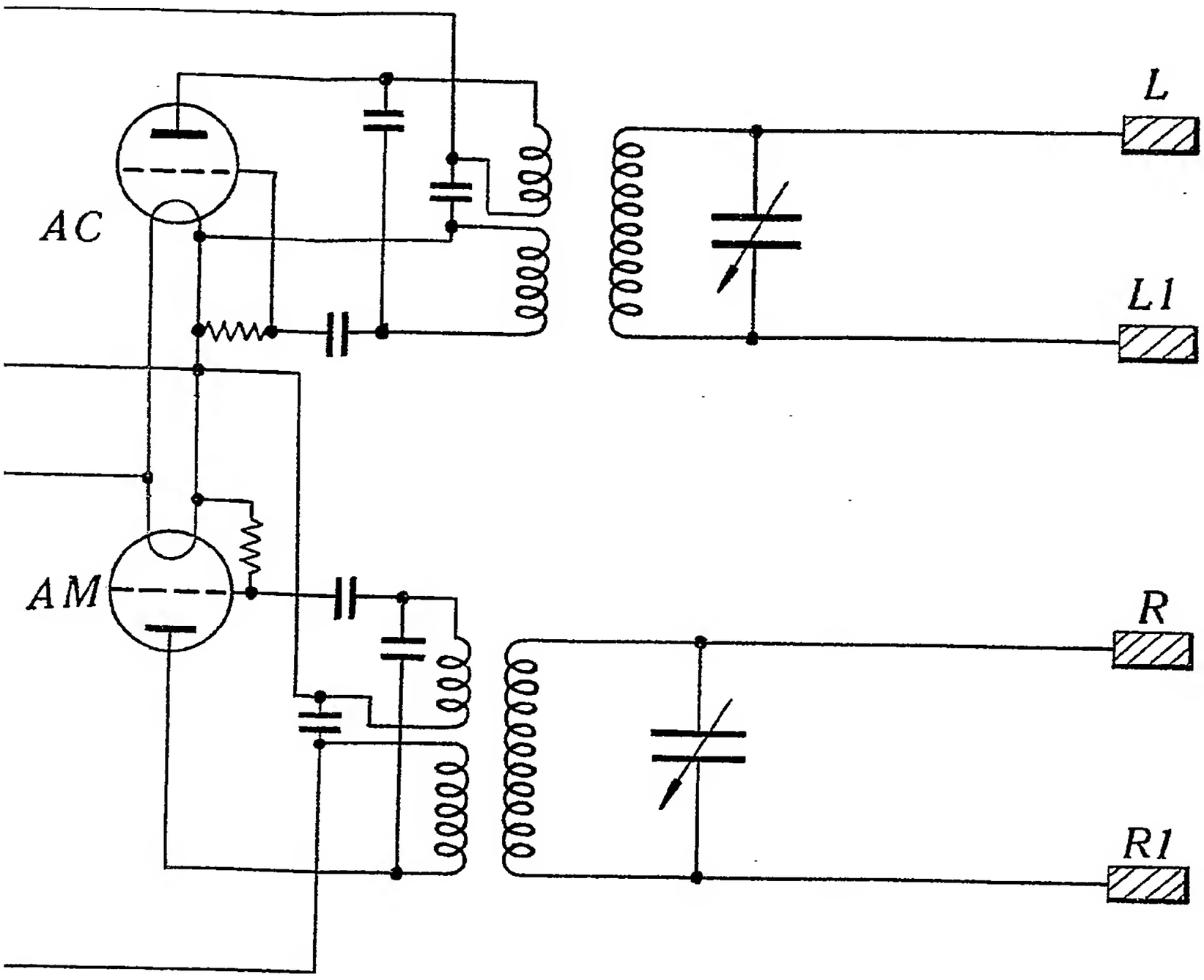

Fig. 6.

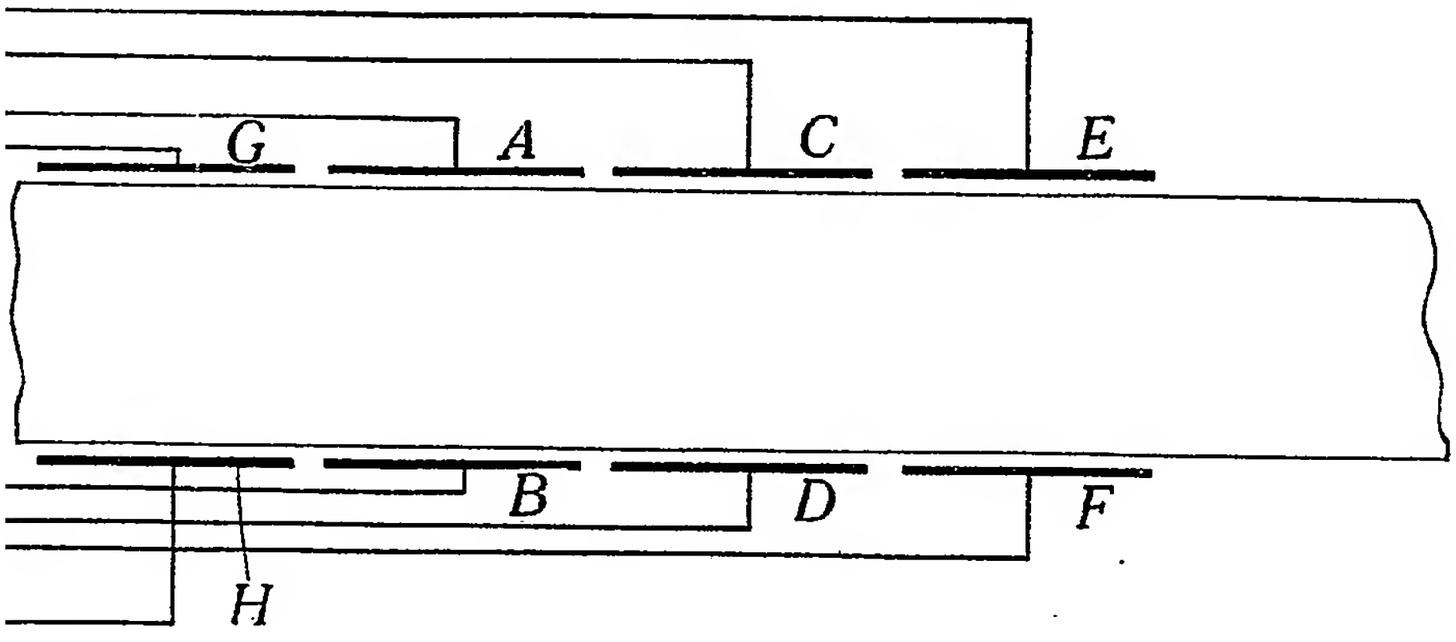

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Fig. 5.

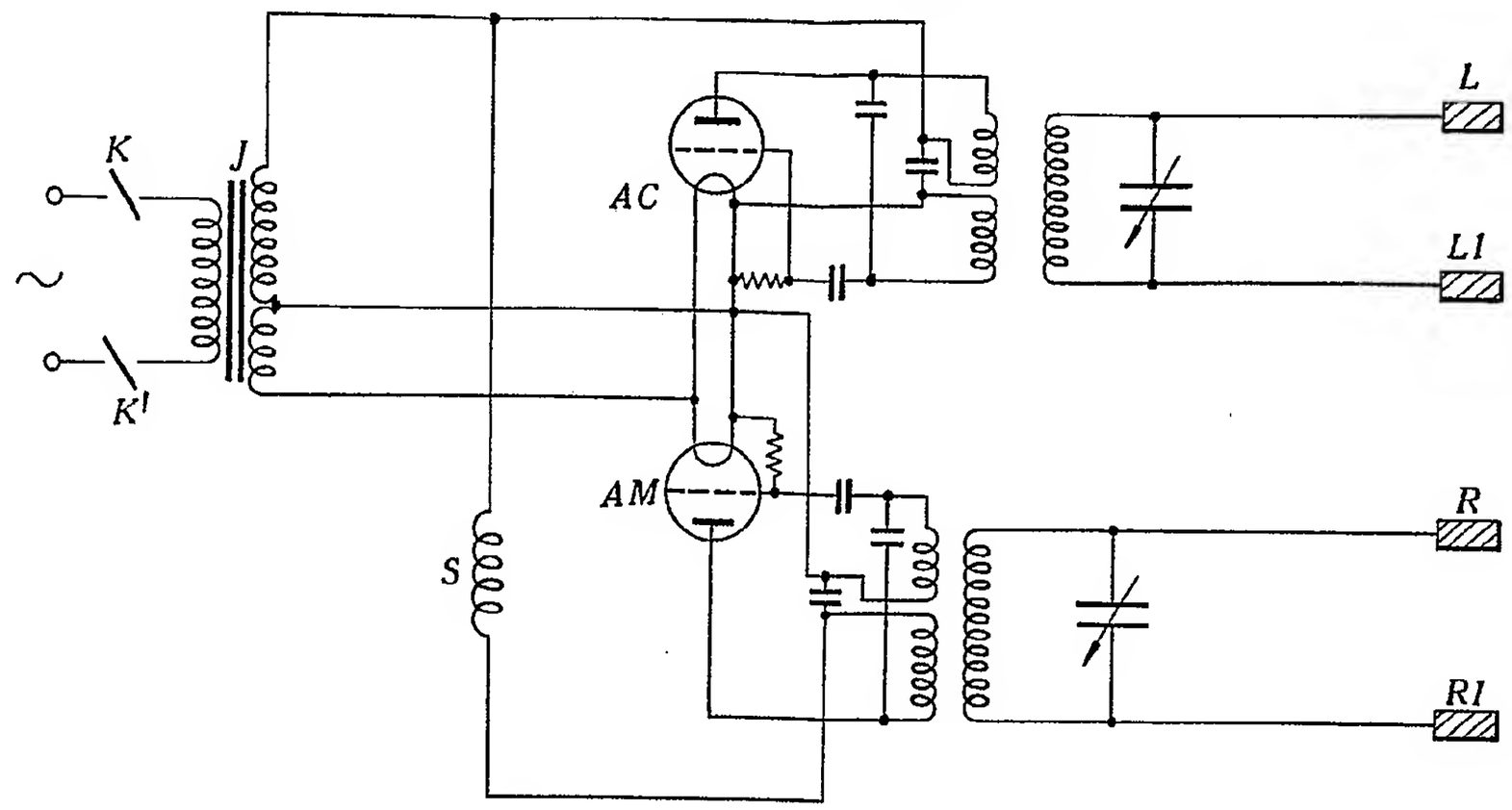
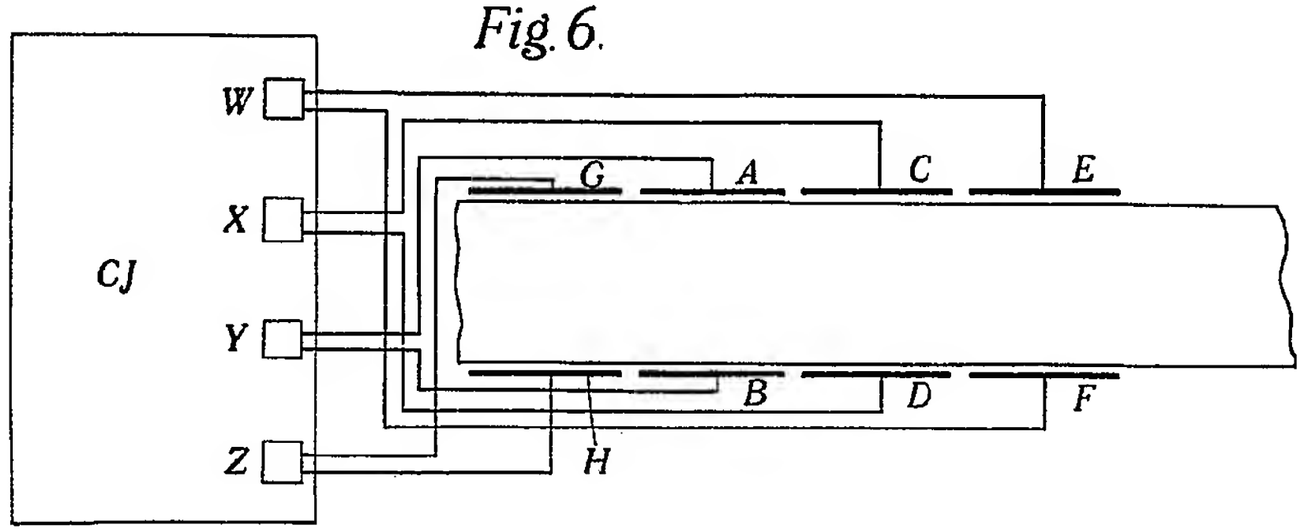


Fig. 6.



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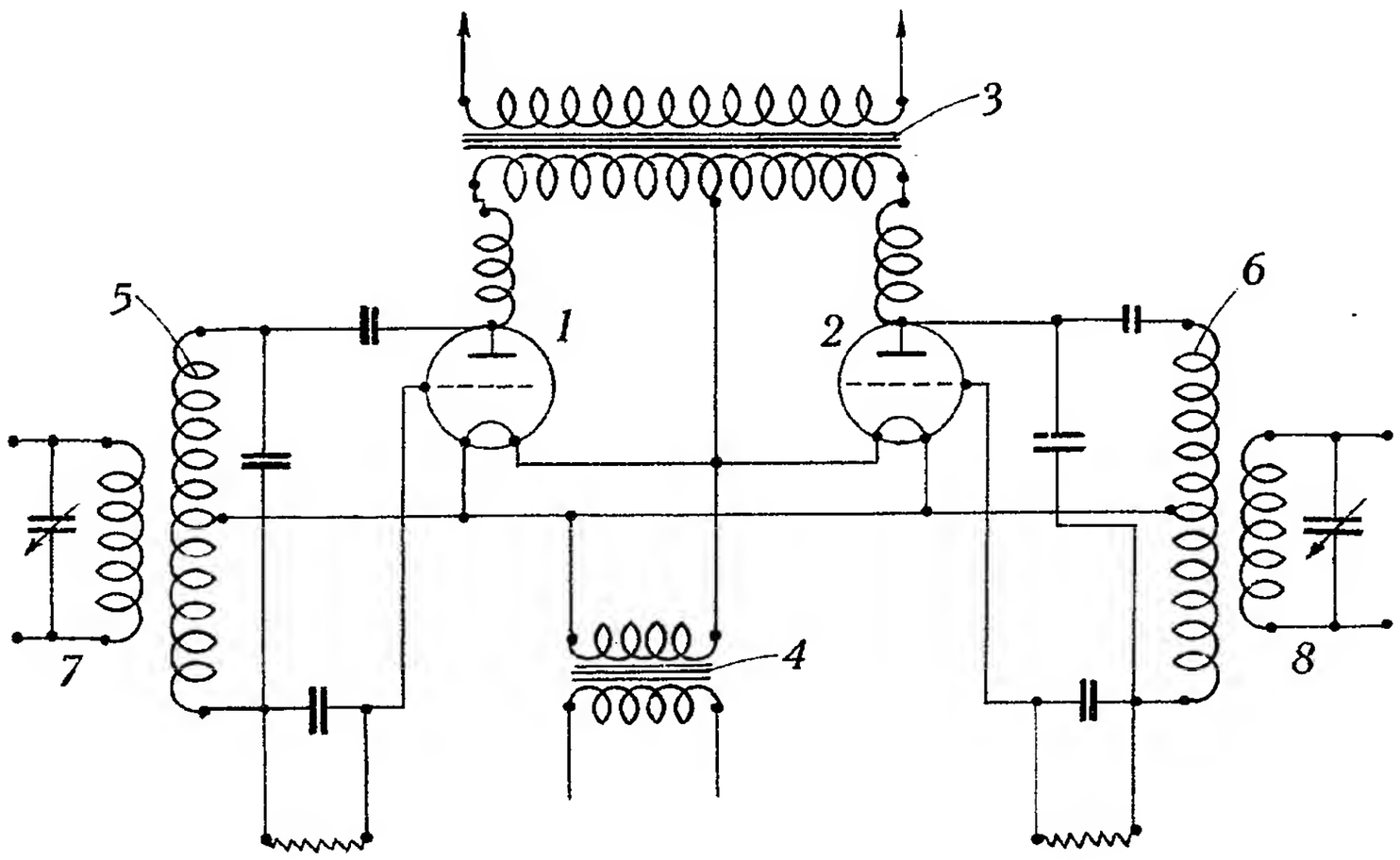

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